EN23 *Window-Wall Ratio (WWR)* (Climate Zones: all)

The window-wall ratio is the percentage resulting from dividing the total glazed area of the building by the total wall area. For any given WWR selected between 20% and 40%, the recommended values for U-factor and SHGC contribute toward the 30% savings target of the entire building. A reduction in the overall WWR ratio will also save energy, especially if glazing is significantly reduced on the east and west façades. Reducing glazing on east and west facades for energy reduction should be done while maintaining consistency with the needs for view, daylighting, and passive solar strategies.

Window Design Guidelines for Thermal Conditions

Uncontrolled solar heat gain is a major cause of energy consumption for cooling in warmer climates and thermal discomfort for occupants. Appropriate configuration of windows according to the orientation of the wall on which they are placed can significantly reduce these problems.

EN24 *Solar Heat Gain Is Most Effectively Controlled on the Outside of the Building* (Climate Zones: all)

Significantly greater energy savings are realized when sun penetration is blocked before entering the windows. Horizontal overhangs located at the top of the windows are most effective for south-facing façades and must continue beyond the width of the windows to adequately shade them. The vertical extension of the overhang depends on the latitude and the climate (see Figure 4-17). Vertical fins oriented slightly north are most effective for east- and west-facing façades. Consider louvered or perforated sun control devices, especially in primarily overcast and colder climates, to prevent a totally dark appearance in those environments.

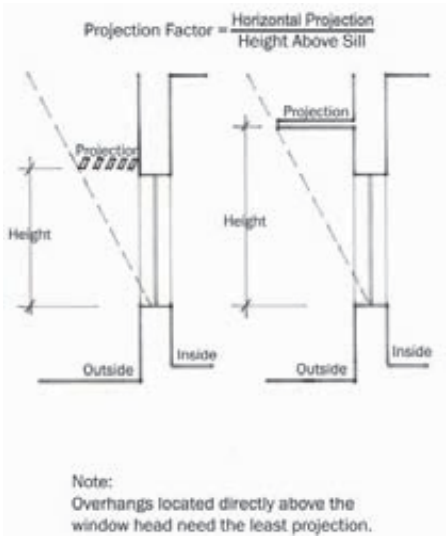

Figure 4-17. (EN24) Windows with overhang.

EN25 *Operable versus Fixed Windows* (Climate Zones: all)

Operable windows offer the advantage of personal comfort control and beneficial connections to the environment. However, individual operation of the windows not in coordination with the HVAC system settings and requirements can have extreme impacts on the energy use of a building's system. Advanced energy buildings with operable windows should strive for a high level of integration between envelope and HVAC system design. First, the envelope should be designed to take advantage of natural ventilation with well-placed operable openings. Second, the mechanical system should employ interlocks on operable windows to ensure that the HVAC system responds by shutting down in the affected zone if the window is opened. It is important to design the window interlock zones to correspond as closely as possible to the HVAC zone affected by the open window.

Warm Climates

EN26

Building Form and Window Orientation (Climate Zones: ❶ ❷ ❸ ❹ ❺ ❻)

In warm climates, north and south glass can be more easily shielded and can result in less solar heat gain and less glare than do east- and west-facing glass. During site selection, preference should be given to sites that permit elongating the building in the east-west direction and that permit orienting more windows to the north and south. See Figure 4-18.

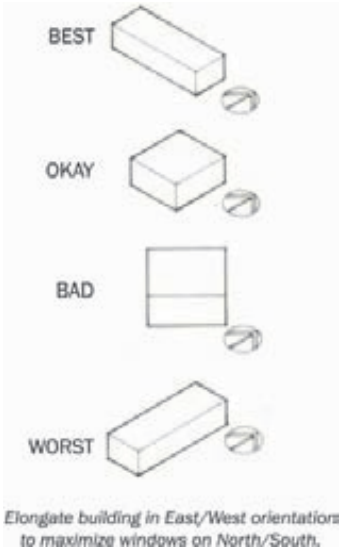

Figure 4-18. (EN26) Building and window orientation.

A good design strategy avoids areas of glass that do not contribute to the view from the building or to the daylighting of the space. If possible, configure the building to maximize north-facing walls and glass by elongating the floor plan. Since sun control devices are less effective on the east and west façades, the solar penetration through the east- and west-facing glazing should be considerably less than that through the north- and south-facing glazing. This can be done by reducing the area of glazing, reducing the SHGC, or preferably both. Thus, the area of glazing on the east and west façades, times their respective SHGCs, should be less than the area of glazing on the north and south façades times their respective SHGCs. If each façade has a different area or SHGC, the formula becomes: ((W window area × W SHGC) + (E window area × E SHGC)) < (less than) ((N window area × N SHGC) + (S window area × S SHGC)). For buildings where a predominantly east-west exposure is unavoidable, or if the application of this equation would result in SHGCs of less than 0.25, then more aggressive energy conservation measures may be required in other building components to achieve an overall 30% energy savings.

EN27

Glazing (Climate Zones: ❶ ❷ ❸ ❹ ❺ ❻)

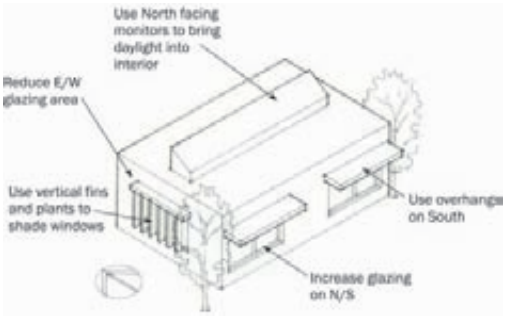

Figure 4-19. (EN27) Exterior sun control.

For north- and south- facing windows, select windows with a low solar heat gain coefficient and an appropriate visible light transmission (VLT). See EN32. Certain window coatings, called selective low-e, transmit the visible portions of the solar spectrum selectively, rejecting the nonvisible infrared sections. These glass and coating selections provide superior view and daylighting, while minimizing solar heat gain. Window manufacturers market special "solar low-e" windows for warm climates. For buildings in warm climates that do not utilize daylight-responsive lighting controls, north and south window glazing should be selected with a solar heat gain coeffi-

cient (SHGC) of no more than 0.35. East- and west-facing windows in warm climates should be selected for an SHGC of no more than 0.25. All values are for the entire fenestration assembly, in compliance with NFRC procedures, and are not simply center-of-glass values. For warm climates, a low SHGC is much more important for low building energy consumption than the window assembly U-factor. Windows with low SHGC values will tend to have a low center-of-glass U-factor, however, because they are designed to reduce the conduction of the solar heat gain absorbed on the outer light of glass through to the inside of the window.

EN28 ***Obstructions and Planting* (Climate Zones: all)**

Adjacent taller buildings and trees, shrubs, or other plantings are effective to shade glass on south, east, and west façades. For south-facing windows, remember that the sun is higher in the sky during the summer, so that shading plants should be located high above the windows to effectively shade the glass. See Figure 4-19. The glazing of fully shaded windows can be selected with higher SHGC ratings without increasing energy consumption. The solar reflections from adjacent building with reflective surfaces (metal, windows or especially reflective curtain walls) should be considered in the design. Such reflections may modify shading strategies, especially on the north façade.

Cold Climates

EN29 ***Window Orientation* (Climate Zones: all)**

For more northerly locations, only the south glass receives much sunlight during the cold winter months. If possible, maximize south-facing windows by elongating the floor plan in the east-west direction and relocate windows to the south face. Be careful to install blinds or other sun control devices for the south-facing glass that allow for passive effects when desired but prevent unwanted glare and solar overheating. Glass facing east and west should be significantly limited. Areas of glazing facing north should be cautiously sized for daylighting and view. During site selection, preference should be given to sites that permit elongating the building in the east-west direction and that permit orienting more windows to the south. See also DL5 and Figure 4-18.

EN30 ***Passive Solar* (Climate Zones: all)**

Passive solar energy-saving strategies should be limited to non-office spaces, such as lobbies and circulation areas, unless those strategies are designed so that workers do not directly view interior sun patches or see them reflected in computer screens. Consider heat-absorbing blinds. In spaces where glare is not an issue, the usefulness of the solar heat gain collected by these windows can be increased by using hard massive floor surfaces, such as tile or concrete, in the locations where the transmitted sunlight will fall. These floor surfaces absorb the transmitted solar heat gain and release it slowly over time, to provide a more gradual heating of the structure. Consider low-e glazing with exterior overhangs.

EN31 ***Glazing* (Climate Zones: all)**

Higher SHGCs are allowed in colder regions, but continuous horizontal overhangs are still necessary to block the high summer sun angles. Window manufacturers market low-e windows designed especially for cold climates.